

### **REMARKS**

Applicants appreciate the thorough examination as reflected in the Official Action mailed November 21, 2002. Applicants have amended Claims 8, 13, 16 and 20 to clarify the nature of the claimed invention. Applicants have also amended the specification to provide the serial number of the present application's parent application in the "Related Applications" section of the specification.

#### **The IDS**

Applicants wish to bring to the Examiner's attention an IDS filed herewith. Applicants appreciate the return of initialed PTO-1449 forms for Applicants' previous IDS submissions and request the same for the IDS submitted with the present Amendment.

#### **The Section 112 Rejections**

Claims 8, 13 and 16 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. Applicants have amended Claim 8 to make it clear that "another processing step" is a processing step other than a processing step that is only a hydrogen anneal. Support for this amendment is provided at least at page 7, line 18 to page 8 line 6 of the present Specification.

Applicants have amended Claim 13 to insert the definition of "high temperature" provided in the Specification at page 8, lines 4 and 5. Thus, Claim 13 recites that the subsequent processing steps are carried out at a temperature of about 400 °C or greater.

Claim 16 has been amended to make clear that "contact anneal" in Claim 16 refers to a "metal contact anneal," for example, to provide an ohmic contact to a semiconductor material. Such a contact anneal is described, for example, in the Specification at page 7, line 18 to page 8, line 6.

In light of the above discussion, Applicants submit that the rejections based on § 112 have been overcome.

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### The Section 103 Rejections

Claims 1-20 stand rejected as obvious under 35 U.S.C. § 103 based on the combination of Japanese published application JP 2000-252461 to Arai *et al.* (hereinafter "Arai") and the article Xu *et al.*, "Improved Performance and Reliability of N<sub>2</sub>O Grown Oxynitride on 6H-SiC," IEEE Electron Device Letters, Col. 21, no. 6, June 2000, pp. 298-300 (hereinafter "Xu"). Claims 1 and 20 are independent claims. Claim 1 recites:

fabricating a nitrided oxide layer on a layer of silicon carbide; and  
annealing the nitrided oxide layer in an environment containing hydrogen.

Applicants respectfully submit that Claim 1 is patentable over Arai and Xu as Arai and Xu do not suggest the recitations of Claim 1 or provide an expectation of success.

To establish a *prima facie* case of obviousness, the prior art reference or references when combined must teach or suggest *all* the recitations of the claims, and there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. M.P.E.P. §2143. The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. M.P.E.P. §2143.01, citing *In re Mills*, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990). As emphasized by the Court of Appeals for the Federal Circuit, to support combining references, evidence of a suggestion, teaching, or motivation to combine must be **clear and particular**, and this requirement for clear and particular evidence is not met by broad and conclusory statements about the teachings of references. *In re Dembiczak*, 50 U.S.P.Q.2d 1614, 1617 (Fed. Cir. 1999). The Court of Appeals for the Federal Circuit has also stated that, to support combining or modifying references, there must be **particular** evidence from the prior art as to the reason the skilled artisan, with no knowledge of the claimed invention, would have selected these components for combination in the manner claimed. *In re Kotzab*, 55 U.S.P.Q.2d 1313, 1317 (Fed. Cir. 2000).

The Official Action states that Arai "does not teach that the oxide or nitride layer is a nitrided oxide layer" but that because Arai describes an oxide and a nitride would have suggested that a mixture of the two would be suitable. Official Action, p. 3. Applicants

respectfully submit that because two different materials are used in Arai, that such does not suggest a mixture of the two. Furthermore, Applicants submit that merely because a hydrogen anneal is reported as improving an oxide or a nitride that such does not suggest that a hydrogen anneal would be effective at improving a nitrided oxide. For example, if the problems of an oxide or a nitride that are improved by the hydrogen anneal are not present in a nitrided oxide, then the hydrogen anneal may not improve the nitrided oxide. As is clear from the examples in the present application, a nitrided oxide provides improved interface state densities over only an oxide. It is not clear from the cited references that further improvements would be suggested by a hydrogen anneal of such a nitrided oxide. *See e.g.* Xu, Summary and Suzuki discussed below. Accordingly, Applicants submit that annealing a nitrided oxide layer in a hydrogen environment is neither disclosed nor suggested by Xu or Arai.

Claim 20 has been amended to clearly recite that "the oxide layer" that is nitrided is an existing oxide layer. Thus, Claim 20 recites:

nitriding the existing oxide layer on the silicon carbide layer with at least one of nitric oxide and nitrous oxide; and  
annealing the nitrided oxide layer at a temperature of between about 400 °C about 900 °C in a hydrogen containing environment for at least about 2 minutes.

Thus, Claim 20 recites nitriding an existing oxide layer and annealing in a hydrogen containing environment.


Applicants respectfully submit that Xu describes improvements resulting from growth of a nitrided oxide layer whereas Claim 20 recites nitriding an existing oxide layer, for example, by an anneal in nitric or nitrous oxide. Furthermore, Xu concludes that N<sub>2</sub>O grown oxides had "much smaller flat-band voltage shift than N<sub>2</sub>O-nitrided and thermal oxide devices." Xu, Summary. Xu also states that "[a]ll these gains are attributed to significant nitrogen incorporation near the SiC/SiO<sub>2</sub> interface during N<sub>2</sub>O oxidation." Xu, Summary. While Applicants acknowledge that work has been done on NO and N<sub>2</sub>O annealing of an oxide to provide a nitride oxide, for example, as described in Li *et al.*, "Improving SiO<sub>2</sub> Grown on P-Type 4H-SiC by NO Annealing," Materials Science Forum, Vols. 264-268

(1998), pp. 869-872, Applicants submit that Xu provides no basis for combining a nitrided existing oxide layer with a hydrogen anneal.

Similarly, Applicants acknowledge that work has been done on post oxidation annealing in hydrogen, for example, as described in Suzuki *et al.*, "Effect of Post-oxidation-annealing in Hydrogen on SiO<sub>2</sub>/4H-SiC Interface," Material Science Forum, Vols. 338-342, pp. 1073-1076, 2000, Applicants submit that such work does not provide a basis for combining a nitrided existing oxide layer with a hydrogen anneal. In fact, the improvements in D<sub>it</sub> provided by hydrogen anneals of thermal oxides described in Suzuki were viewed as related to the concentration of hydrogen at the SiC/SiO<sub>2</sub> interface. Suzuki, pp. 1075-76 and Figure 5. However, as discussed above, Xu indicates that the incorporation of nitrogen at the SiC/SiO<sub>2</sub> interface is the reason for improvements in N<sub>2</sub>O grown oxides. Xu, Summary, p. 300. Applicants submit that because the incorporation of hydrogen or nitrogen at the interface is viewed as the mechanism that provides a benefit, one of skill in the art would not be motivated to combine nitridation and a hydrogen anneal as both are viewed as performing a similar function.

In light of the above discussion, Applicants submit that neither Arai nor Xu disclose or suggest annealing a nitrided existing oxide layer in a hydrogen containing environment as recited in Claim 20. Accordingly, Applicants submit that Claim 20 is patentable over the cited references.

While Applicants submit that each of the dependent claims are patentable as depending from a patentable base claim, Applicants also submit that certain of the dependent claims are separately patentable over Arai and Xu. For example, Claim 7 recites that "the step of annealing the oxide layer in an environment containing hydrogen is provided substantially concurrently with the step of fabricating the nitride layer." In rejecting Claim 7, the Official Action states that "performing two steps simultaneously, which have previously been performed in sequence, is considered to be obvious." Official Action, p. 4. However, neither Arai nor Xu suggest that the oxide growth and the hydrogen anneal could be carried out simultaneously. While Arai does say that other gases may be used when the hydrogen anneal is performed, Arai describes these gases as "inert." Arai translation, ¶16. Arai only



describes an anneal with inert nitrogen which would not result in a nitrided oxide. As such, Applicants submit that there would be no motivation to combine Arai and Xu in the manner recited in Claim 7 and no expectation of success even if combined. Accordingly, Applicants submit that Claim 7 is separately patentable over Arai and Xu for at least these additional reasons.

Claim 8 recites that "the step of annealing the oxide layer comprises heating the oxide layer to a temperature of greater than about 400 °C in a hydrogen containing environment as part of a processing step other than a processing step comprising only a hydrogen anneal of the oxide layer." Neither Xu nor Arai disclose or suggest that a hydrogen anneal may be provided as part of a separate processing step as recited in Claim 8. Accordingly, Applicants submit that Claim 8 is separately patentable over Arai and Xu for at least these additional reasons.

Claim 10 recites "annealing the oxide layer at a temperature of less than about 900 °C in a hydrogen containing environment." Such an anneal temperature may be beneficial because it may reduce damage to other portions of the semiconductor device that may result from use of higher temperatures. Arai does not disclose such an upper limit on the anneal temperature. Accordingly, Applicants submit that Claim 10 is separately patentable over Arai and Xu for at least these additional reasons.

Claim 13 recites "performing subsequent processing steps carried out at temperatures of about 400 °C or greater in a hydrogen containing environment." Neither Xu nor Arai disclose or suggest that subsequent high temperature processing steps be carried out in a hydrogen containing environment. Accordingly, Applicants submit that Claim 13 is separately patentable over Arai and Xu for at least these additional reasons.

Claim 14 recites that "the step of annealing is preceded by the step of forming metallization for a semiconductor device associated with the oxide layer." (emphasis added). Arai specifically describes forming the capacitor contacts after the hydrogen anneal. Arai translation, Example. Neither Xu nor Arai disclose or suggest that metallization be formed before the hydrogen anneal. Similarly, Claim 16 recites that "the step of annealing the oxide layer comprises a metal contact anneal." Applicants submit that annealing a nitrided oxide

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layer as part of a metal contact anneal is neither disclosed nor suggested by either XU or Arai. Accordingly, Applicants submit that Claim 14 and 16 are separately patentable over Arai and Xu for at least these additional reasons.

### **CONCLUSION**

In light of the above discussion, Applicant submits that the present application is in condition for allowance, which action is respectfully requested. If, in the opinion of the Examiner, a telephonic conference would expedite the examination of this matter, the Examiner is invited to call the undersigned attorney at (919) 854-1400.

It is not believed that an extension of time and/or additional fee(s)-including fees for net addition of claims-are required, beyond those that may otherwise be provided for in documents accompanying this paper. In the event, however, that an extension of time is necessary to allow consideration of this paper, such an extension is hereby petitioned under 37 C.F.R. §1.136(a). Any additional fees believed to be due in connection with this paper may be charged to our Deposit Account No. 50-0220.

Respectfully submitted,



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**20792**

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### **CERTIFICATE OF MAILING**

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, Washington, DC 20231 on February 20, 2003.



Traci A. Brown

Date of Signature: February 20, 2003

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